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Fujiwara et al.

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(54) **VEHICLE FUEL VAPOR RECOVERY SYSTEM**

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USPC 141/286
See application file for complete search history.

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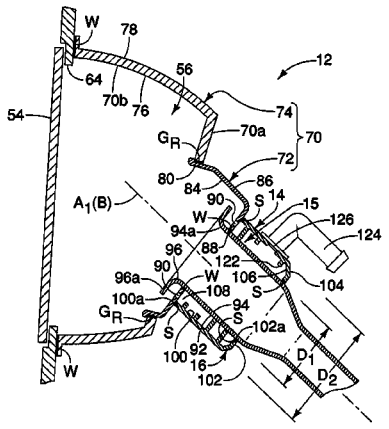
(57) **ABSTRACT**

A vehicle fuel filler tube collar includes an end wall and a side wall. The end wall has an inner surface and an outer surface with a first tube receiving surface extending from the inner surface to the outer surface. The tube receiving surface defines a tube receiving opening having a first diameter. The side wall extends from the end wall and has a first end that is contiguous with the end wall and a second end opposite the end wall. The side wall has an inner collar surface that defines a vent opening at the second end, and an outer collar surface. The vent opening at the second end has a second diameter larger than the first diameter.

13 Claims, 7 Drawing Sheets



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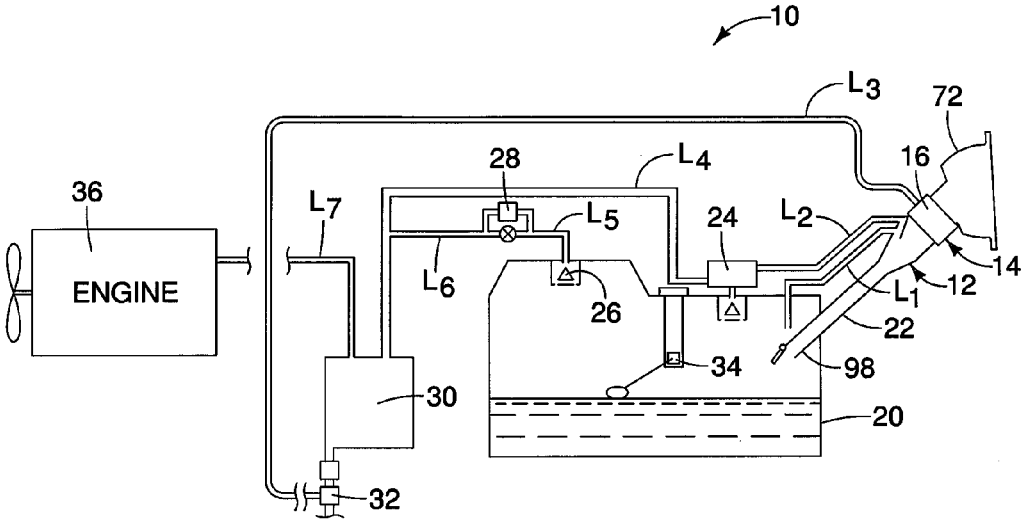
10
L3
72
28
L4
16
36
L7
L5
24
L2
14
ENGINE
L6
26
L1
12
22
34
98
30
20
32

FIG. 1

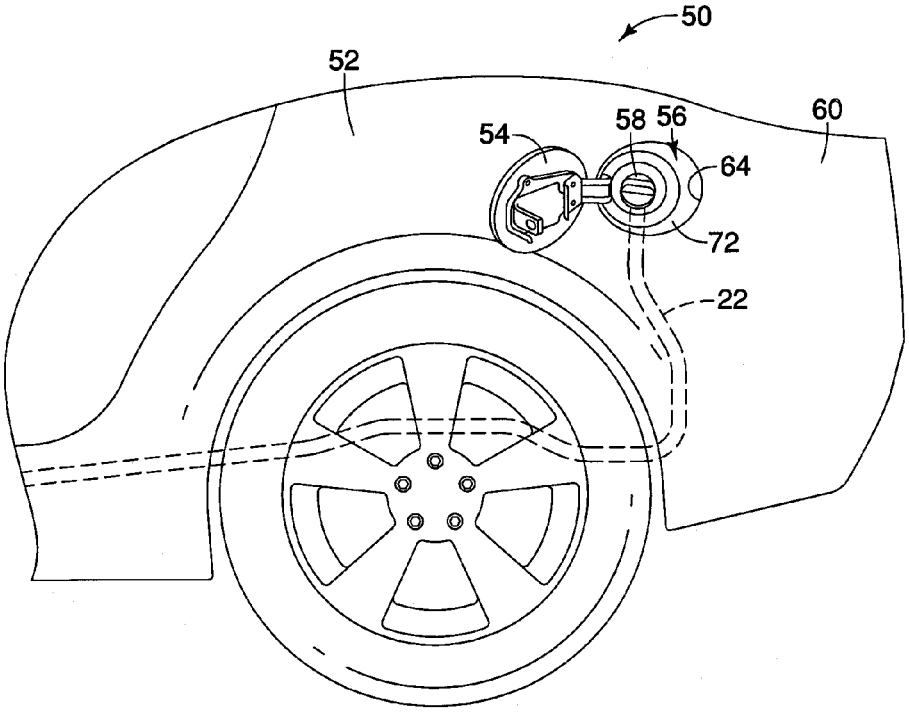
50
52
60
54
58
56
64
72
22

FIG. 2

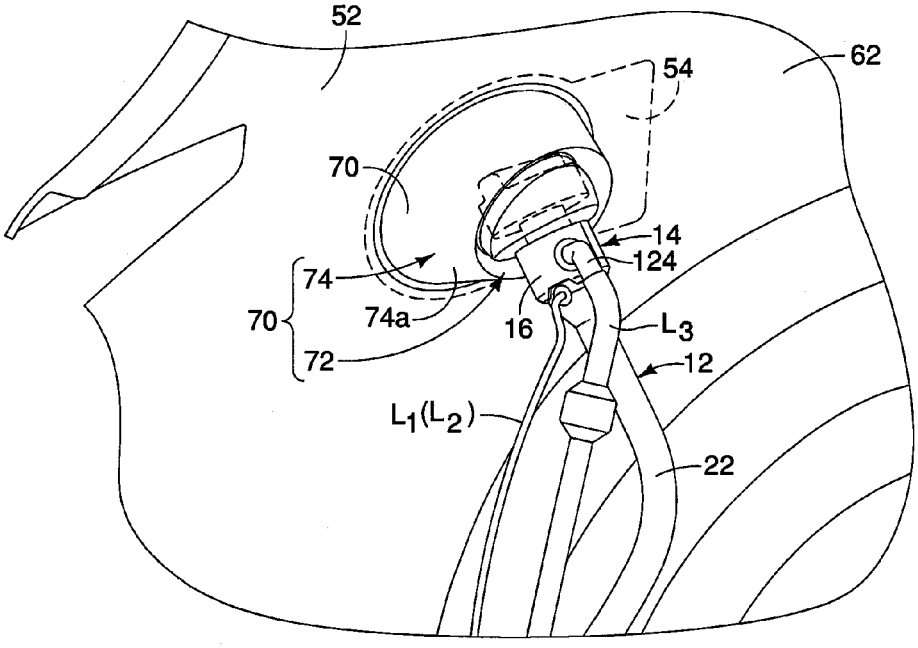
52
62
54
70
14
124
74
70
74a
16
L3
72
12
L1(L2)
22

FIG. 3

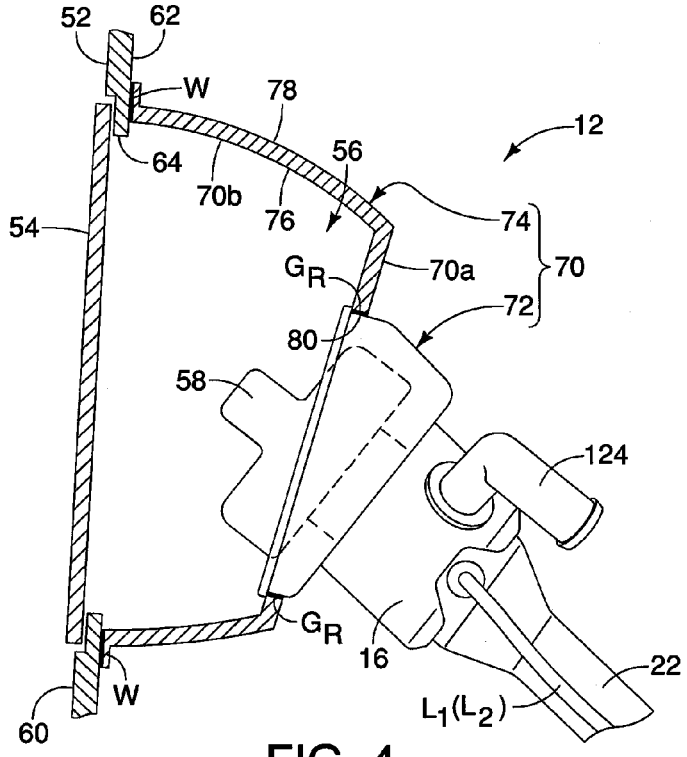
52
62
W
78
12
64
56
70b
76
74
54
GR
70a
70
72
80
58
124
GR
16
22
W
60
L1(L2)

FIG. 4

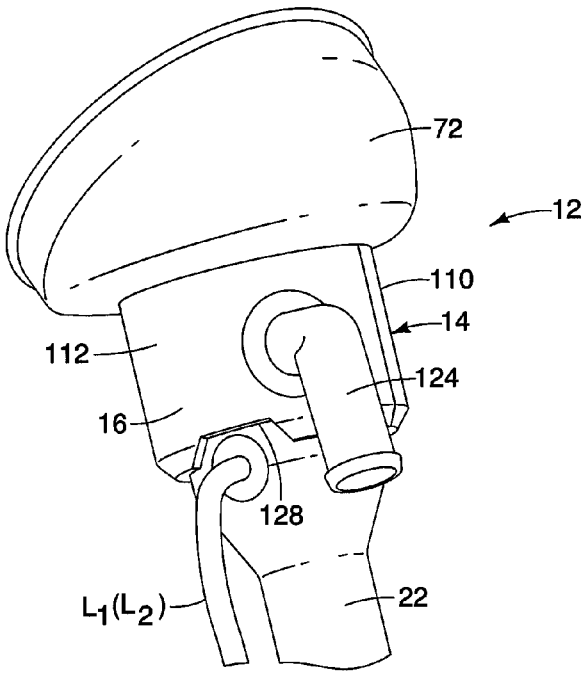
72
12
110
14
112
124
16
128
$L_1(L_2)$
22

FIG. 5

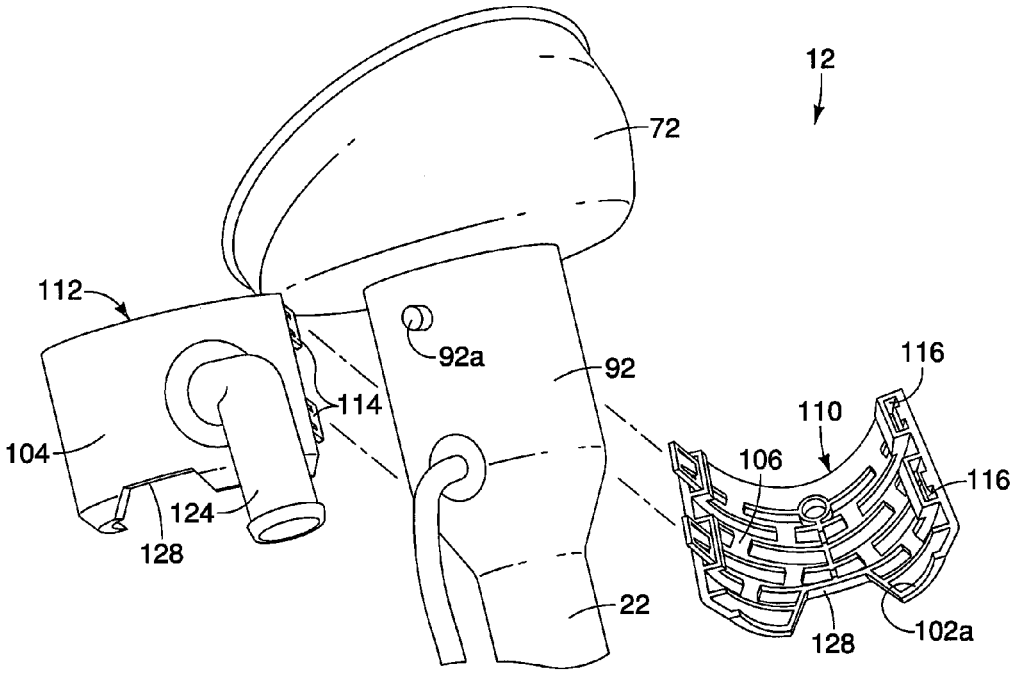
12
72
112
92a
92
116
110
114
106
104
116
124
128
22
128
102a

FIG. 6

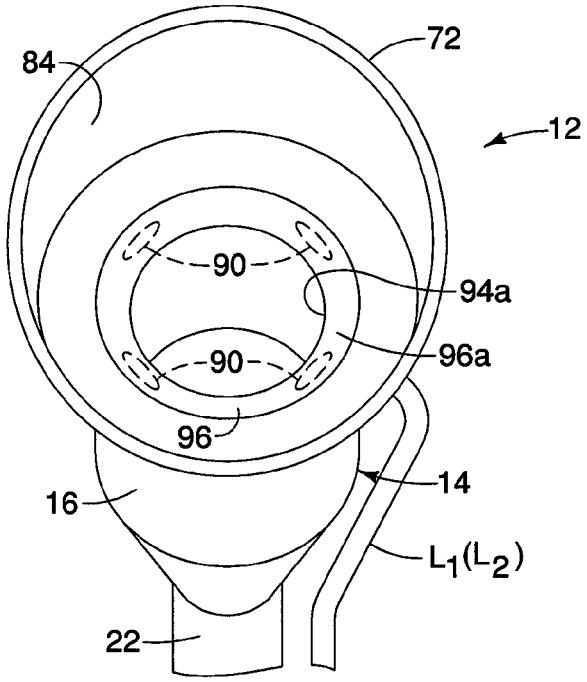
84
72
12
90
94a
90
96a
96
14
16
$L_1(L_2)$
22

FIG. 7

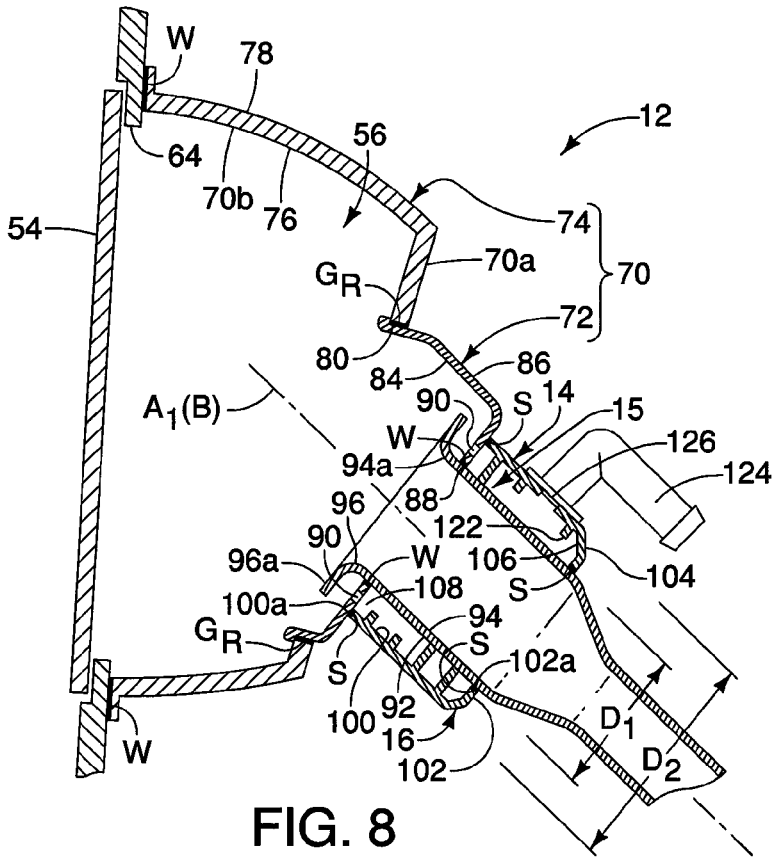
W
78
12
56
64
70b
76
74
54
70a
70
G_R
72
80
84
86
$A_1(B)$
90
S
14
15
W
126
94a
124
96
88
122
90
96a
W
106
104
108
S
100a
94
G_R
S
S
102a
100
92
16
102
W
D_1
D_2

FIG. 8

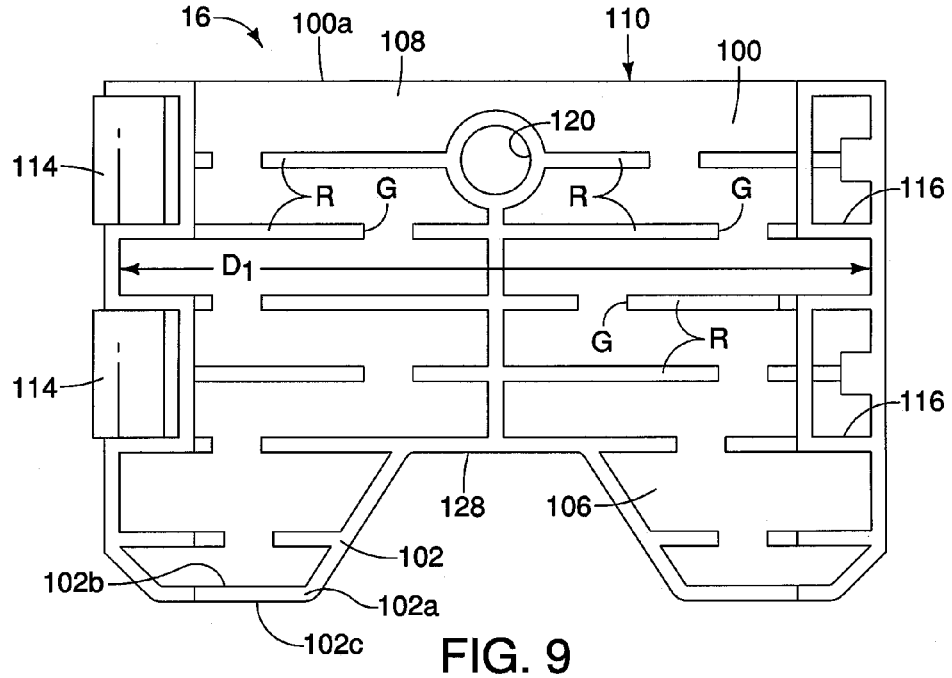
16
100a
108
110
100
120
114
R
G
R
G
116
D1
G
R
114
116
128
106
102
102b
102a
102c

FIG. 9

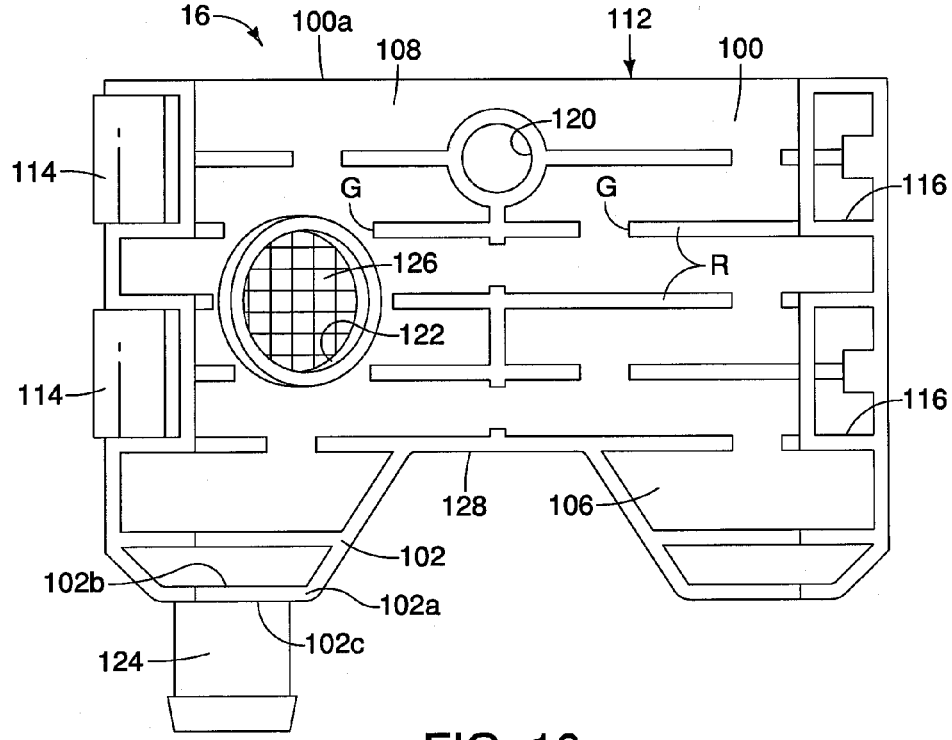
16
100a
108
112
100
120
114
G
G
116
126
R
122
114
116
128
106
102
102b
102a
102c
124

FIG. 10

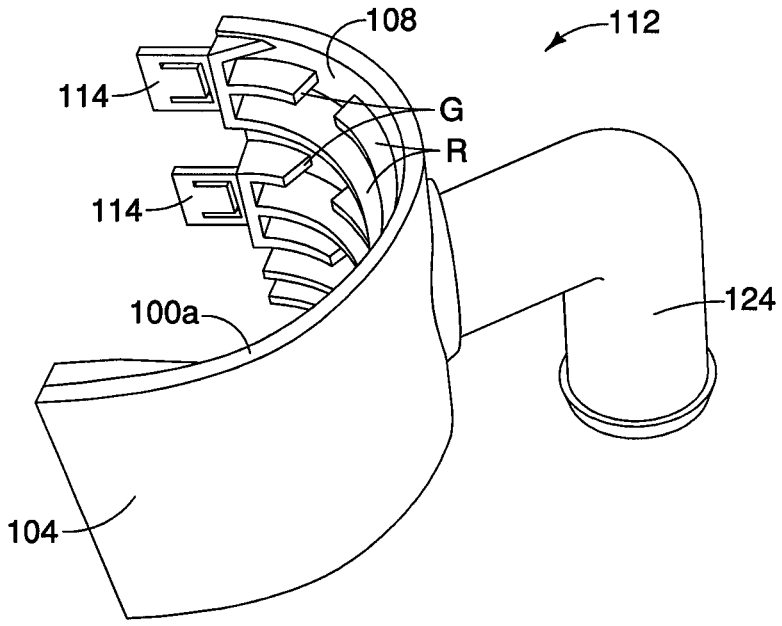
108
112
114
G
R
114
124
100a
104

FIG. 11

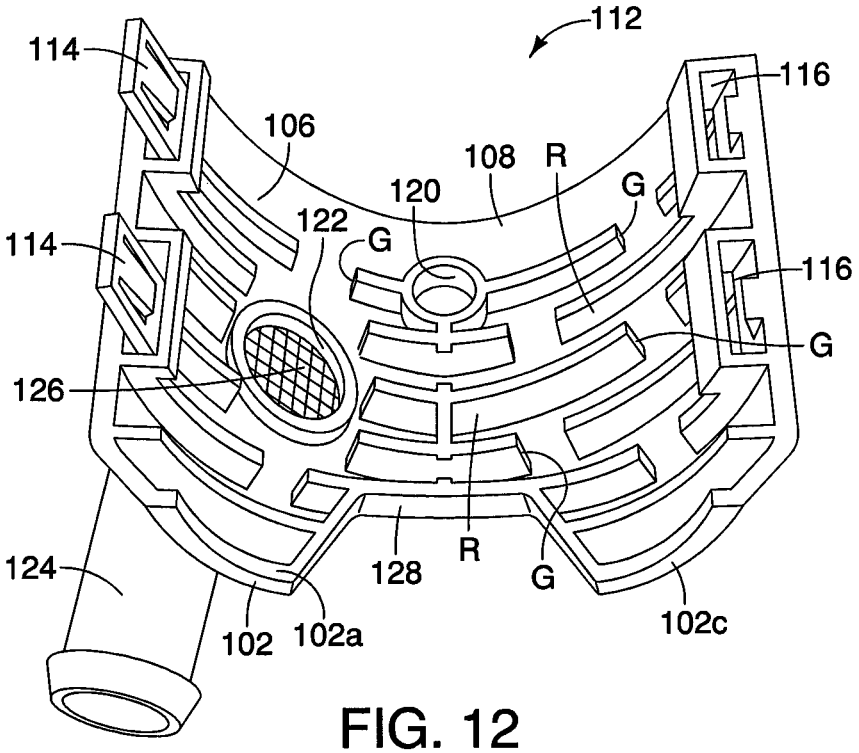
112
114
116
106
108
R
120
G
122
G
114
116
G
126
R
G
124
128
102
102a
102c

FIG. 12

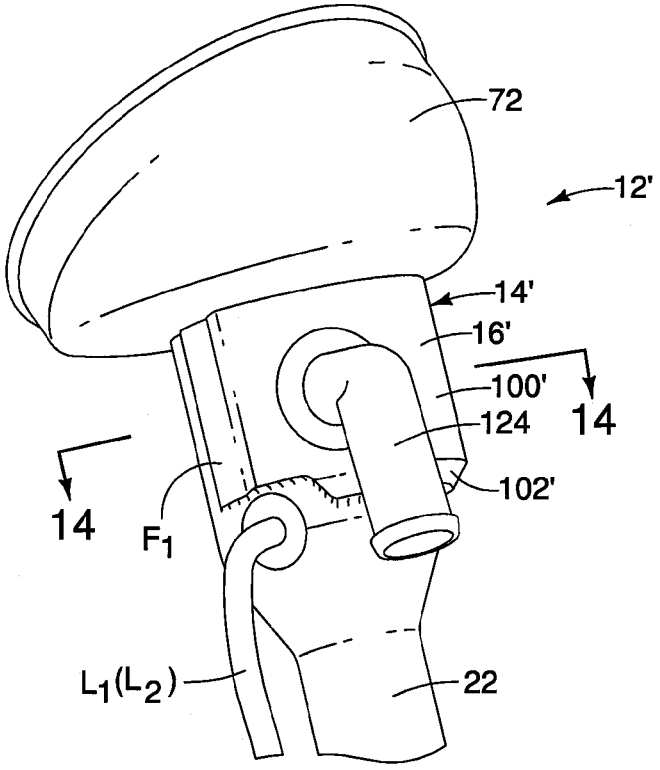
72
12'
14'
16'
100'
124
14
14
F_1
102'
$L_1(L_2)$
22

FIG. 13

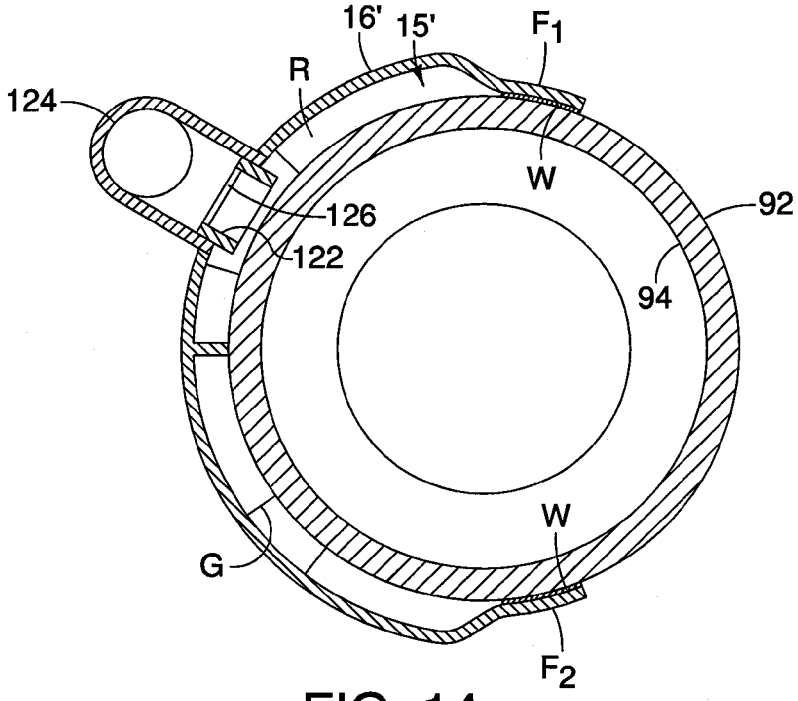
16'
15'
F_1
R
124
W
92
126
122
94
W
G
F_2

FIG. 14

VEHICLE FUEL VAPOR RECOVERY SYSTEM

BACKGROUND

1. Field of the Invention

The present invention generally relates to a vehicle fuel vapor recovery system. More specifically, the present invention relates to a vehicle fuel vapor recovery system that includes a vent structure located at a fuel filler tube of a vehicle.

2. Background Information

During a vehicle refueling process, as fuel fills a fuel tank of the vehicle, air within the fuel tank is displaced. The displaced air typically includes hydrocarbon compounds that have vaporized from the liquid fuel within the fuel tank. New vehicles are typically equipped a fuel vapor recovery system that includes a charcoal filled filter canister. The filter canister is configured to capture the hydrocarbons present in air escaping from the fuel tank during a vehicle refueling process.

Later, when the engine of the vehicle is operating, the fuel vapor recovery system is configured such that fresh air is allowed to flow into the filter canister, drawing the hydrocarbons out of the filter canister. This fresh air and the captured hydrocarbons are then fed into the engine and combusted along with liquid fuel from the fuel tank. The filter canister is connected to a vent that is positioned to draw the fresh air in when the engine is operating. The vent is typically located somewhere under a fender or other body panel of the vehicle drawing air in from under the vehicle.

SUMMARY

One object of the disclosure is to provide a fuel vapor recovery system of a vehicle with a protected air vent chamber that vents air to a fuel filler compartment and also draws fresh air in from the fuel filler compartment.

Another object of the disclosure is to provide a fuel vapor recovery system of a vehicle with an air vent for a vehicle fuel vapor recovery system that is protected from weather extremes and outdoor debris.

In view of the state of the known technology, one aspect of the disclosure a vehicle fuel filler tube collar includes an end wall and a side wall. The end wall has an inner surface and an outer surface with a first tube receiving surface extending from the inner surface to the outer surface. The tube receiving surface defines a tube receiving opening having a first diameter. The side wall extends from the end wall and has a first end that is contiguous with the end wall and a second end opposite the end wall. The side wall has an inner collar surface that defines a vent opening at the second end, and an outer collar surface. The vent opening at the second end has a second diameter larger than the first diameter.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the attached drawings which form a part of this original disclosure:

FIG. **1** is a schematic view of a fuel vapor recovery system of a vehicle that includes an air vent chamber that is connected to a fuel filler compartment in accordance with a first embodiment;

FIG. **2** is a side view of a rearward portion of a vehicle showing an exterior surface of a side body panel that at least partially defines the fuel filler compartment of the fuel vapor recovery system in accordance with the first embodiment;

FIG. **3** is perspective view of the rearward portion of a vehicle showing an interior (hidden) surface of the side body panel, the fuel filler compartment and the air vent chamber of the fuel vapor recovery system in accordance with the first embodiment;

FIG. **4** is a partial cross-sectional view of the side body panel showing details of the fuel filler compartment, and a fuel filler tube assembly that includes a cap protector, a fuel filler tube and a collar that at least partially define the air vent chamber in accordance with the first embodiment;

FIG. **5** is a perspective view the fuel filler tube assembly removed from the side body panel and the fuel filler compartment showing the cap protector, the fuel filler tube and the collar of the air vent chamber in accordance with the first embodiment;

FIG. **6** is an exploded view of the fuel filler tube assembly showing the cap protector, the fuel filler tube and two half collar sections that define the collar in accordance with the first embodiment;

FIG. **7** is a plan view of the fuel filler tube assembly showing the cap protector and a fuel receiving end of the fuel filler tube in accordance with the first embodiment;

FIG. **8** is a cross-sectional view of the fuel filler compartment and the fuel filler tube assembly showing details of the collar that at least partially forms the air vent chamber in accordance with the first embodiment;

FIG. **9** is a side view of a first half collar section of the collar showing ribs on an inner surface of the first half collar section that define an air flow passageway in accordance with the first embodiment;

FIG. **10** is a side view of a second half collar section of the collar showing ribs on an inner surface of the second half collar section that further define the air flow passageway in accordance with the first embodiment;

FIG. **11** is a perspective view of the second half collar section of the collar showing a tube fitting that is connected to a vent opening of the second half collar section in accordance with the first embodiment;

FIG. **12** is another perspective view of the second half collar section of the collar showing the ribs that define the air flow passageway and the vent opening of the second half collar section in accordance with the first embodiment;

FIG. **13** is a perspective view of a fuel filler tube assembly in accordance with a second embodiment; and

FIG. **14** is a cross-sectional view of the fuel filler tube assembly taken along the line **14-14** in FIG. **13** showing an alternate configuration of an air vent chamber in accordance with the second embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

Selected embodiments will now be explained with reference to the drawings. It will be apparent to those skilled in the art from this disclosure that the following descriptions of the embodiments are provided for illustration only and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

Referring initially to FIG. **1**, a fuel vapor recovery system **10** that includes a fuel filler tube assembly **12** having an air vent chamber structure **14** defining an air vent chamber **15** is illustrated in accordance with a first embodiment. The air vent chamber **15** is partially defined by a collar **16** that is installed to the fuel filler tube assembly **12**, as is described in greater detail below after a brief description of parts of the fuel vapor recovery system **10**.

The fuel vapor recovery system **10** basically includes a fuel tank **20**, a fuel filler tube **22**, a refueling control valve **24**, a vapor cutoff valve **26**, an engine vacuum cut-off valve **28**, a filter canister **30**, a vent valve **32**, a fuel level sensor **34**, the air vent chamber structure **14** and associated vent lines that provide sealed fluid communication between connected elements. Specifically, a first line L_1 connects the fuel filler tube **22** to the fuel tank **20**; a second line L_2 connects the fuel filler tube **22** to the refueling control valve **24**; a third line L_3 connects the air vent chamber **15** to the vent valve **32**; a fourth line L_4 connects the refueling control valve **24** to the filter canister **30**; a fifth line L_5 connects the vapor cutoff valve **26** to the engine vacuum cut-off valve **28**; a sixth line L_6 connects the engine vacuum cut-off valve **28** to the filter canister **30** and a seventh line L_7 connects the filter canister **30** to an intake manifold (not shown) of an engine **36** in a conventional manner.

It should be understood from the drawings and the description herein that a fuel delivery system (not shown) is configured to draw liquid fuel from the fuel tank **20** and deliver it to the engine **36**, while the engine **36** is operating. Since the fuel delivery system (not shown) is a conventional system, further description is omitted for the sake of brevity.

The fuel vapor recovery system **10** is configured to operate the refueling control valve **24**, the engine vacuum cut-off valve **28** and the vent valve **32** to direct vapors exiting the fuel tank **20** during refueling to the filter canister **30**. The filter canister **30** is filled with a hydrocarbon absorbing material, such as, for example, charcoal. The hydrocarbon absorbing material absorbs hydrocarbons during the re-fueling process. Thereafter, while the engine **36** of the vehicle **10** is operating, the refueling control valve **24**, the engine vacuum cut-off valve **28** and the vent valve **32** are operated to draw fresh air in from the air vent chamber **15** via the third line L_3, and pass the fresh air through the filter canister **30**. The fresh air flowing through the filter canister **30** draws the hydrocarbons out of the hydrocarbon absorbing material such that the hydrocarbons are drawn through the line L_7 to the engine **36**, where the hydrocarbons are consumed in the combustion process. The fuel vapor recovery system **10** includes a controller (not shown) that controls the refueling control valve **24**, the engine vacuum cut-off valve **28** and the vent valve **32** and detects the fuel level sensed by the fuel level sensor **34**. One example of the configuration of the controller (not shown) and overall operation of the fuel vapor recovery system **10** is further described in U.S. Patent Application Publication No. 2002/0153374, filed Mar. 29, 2002, (assigned to Nissan Motor Co. Ltd.), which is incorporated herein in its entirety. There are alternative ways of configuring a controller and operating the fuel vapor recovery system **10**.

It should be understood from the drawings and description herein, that the basic elements of the fuel vapor recovery system described in U.S. Patent Application Publication No. 2002/0153374 can be altered and re-arranged in order to achieve the fuel vapor recovery system **10** described herein. However, it should be understood that the specific embodiments described herein include the unique features of the fuel filler tube assembly **12**, and the air vent chamber structure **14** which are not disclosed or suggested in U.S. Patent Application Publication No. 2002/0153374. More specifically, the fuel filler tube assembly **12**, and the air vent chamber structure **14** described herein can be employed with other fuel vapor recovery systems that differ from that disclosed in U.S. Patent Application Publication No. 2002/0153374.

FIG. **2** shows rear portion of a vehicle **50** that includes the fuel filler tube assembly **12**. More specifically, the vehicle **50** includes a side body panel **52**, a fuel door **54**, a fuel filler compartment **56**, with the fuel filler tube **22** exposed with the fuel door **54** in an open position, as shown in FIG. **2**.

As shown in FIGS. **2** and **4**, a removable fuel filler cap **58** is removably installed to the fuel filler tube **22** such that with the removable fuel filler cap **58** installed, the fuel filler tube **22** is sealed off from the fuel filler compartment **56**. However, as is described in greater detail below, when the removable fuel filler cap **58** is installed to the fuel filler tube **22**, the air vent chamber **15** continues to be in fluid communication with the fuel filler compartment **56**.

The side body panel **52** has an exterior surface **60** (FIG. **2**), an interior surface **62** (FIG. **3**) and a compartment opening **64** that extends from the exterior surface **60** to the interior surface **62**, as shown in FIG. **4**. As shown in FIG. **3**, the third line L_3 extends from the fuel filler tube **22** behind the side body panel **52**, hidden from view.

As shown in FIG. **3**, the fuel filler tube assembly **12** and the fuel filler tube **22** extend inward from the fuel filler compartment **56** away from the interior surface **62** and toward the fuel tank **20** (shown in FIG. **1**). The fuel filler tube **22** further extends from the fuel filler compartment **56**, which is described in greater detail below.

It should be understood from the drawings and the description herein, that the fuel filler compartment **56**, fuel filler tube assembly **12** and the fuel filler tube **22** can be installed at any of a variety of locations around the vehicle **10**. Specifically, the fuel filler compartment **56** and the fuel filler tube **22** can be installed within a rear storage area (the trunk) of the vehicle **50**, behind a rear license plate support structure (not shown) or other location of the vehicle **50**. The fuel filler compartment **56** and the fuel filler tube **22** can also be installed at locations around a front portion of the vehicle **50**. In other words, the drawings only depict one location of the fuel filler compartment **56** on the vehicle **50**, but not the only location.

As shown in FIG. **4**, the fuel filler compartment **56** is defined by the side body panel **52**, the fuel door **54** and a compartment wall structure **70**. The compartment wall structure includes an inboard surface **70***a* and an outboard surface **70***b*. As shown in FIG. **4**, the compartment wall structure **70** is further defined by a cap protector **72** and an intermediate wall structure **74**, as is described in greater detail below. However, alternatively, the compartment wall structure **70** can be defined as a single monolithic element, or any combination of the cap protector **72** and the intermediate wall structure **74** as desired or required. For example, the cap protector **72** and the intermediate wall structure **74** can be formed of a single metallic member, molded or pressed to form the combined shapes of the cap protector **72** and the intermediate wall structure **74** that is then welded to the side body panel **52**. Further, the compartment wall structure **70** can be formed as an integral part of the side body panel **52**, where the side body panel **52** is molded or pressed to include the overall shapes and/or functions of the cap protector **72** and the intermediate wall structure **74**.

The fuel door **54** is moveably fixed to the side body panel **52** by a hinge structure for movement between an open position shown in FIG. **2** and a closed position shown in FIG. **4**. In the closed position, the fuel door **54** covers the compartment opening **64** protecting the fuel filler compartment **56**. In the open position, the fuel door **54** exposes the fuel filler tube **22** making refueling possible.

As shown in FIGS. **4** and **8**, the intermediate wall structure **74** is welded to the interior surface **62** of the side body

panel **52** at welds W and surrounds the compartment opening **64** in the side body panel **52**. The intermediate wall structure **74** is dimensioned to provide sufficient space to define an outboard portion of the fuel filler compartment **56** as shown in FIG. **4**. The intermediate wall structure **74** includes an interior surface **76** (interior relative to the fuel filler compartment **56**) that defines a first portion of the outboard surface **70***b* of the compartment wall structure **70**, and an exterior surface **78** that is exposed behind the side body panel **52** and defines a first portion of the inboard surface **70***a* of the compartment wall structure **70**. The intermediate wall structure **74** also includes an opening **80** that extends from the interior surface **76** to the exterior surface **78**.

As shown in FIGS. **7** and **8**, the cap protector **72** includes a first surface **84** and a second surface **86**. The first surface **84** defines a second portion of the outboard surface **70***b* of the compartment wall structure **70**. The second surface **86** defines a second portion of the inboard surface **70***a* of the compartment wall structure **70**. The cap protector **72** further includes a tube receiving opening **88** and a plurality of vent openings **90**. The tube receiving opening **88** and the vent openings **90** extend from the first surface **84** to the second surface **86**. However, the vent openings **90** are circumferentially spaced apart from one another and are spaced radially outward of the tube receiving opening **88**. The cap protector **72** defines an inboard portion of the fuel filler compartment **56** as shown in FIG. **8** and an inboard portion of the compartment wall structure **70**.

The compartment wall structure **70** (the cap protector **72** and the intermediate wall structure **74**) defines the tube receiving opening **88** that extends from the inboard surface **70***a* to the outboard surface **70***b* of the compartment wall structure **70**. A portion of the fuel filler tube **22** extends through the tube receiving opening **88** into the fuel filler compartment **56** and is attached to the compartment wall structure **70** at the tube receiving opening **88** of the cap protector **72**.

As mentioned above, the first surface **84** of the cap protector **72** and the interior surface **76** of the intermediate wall structure **74** at least partially define the fuel filler compartment **56**. Alternatively, the opening **80** of the intermediate wall structure **74** could be made smaller to act as the tube receiving opening **88**, and the fuel filler tube **22** could be inserted into the opening **80** and attached directly to the intermediate wall structure **74**; and the vent openings **90** could be formed in the intermediate wall structure **74** surrounding the opening **80** circumferentially spaced apart from one another and spaced radially outward from the opening **80**.

It should be understood from the drawings and the description herein, that the compartment wall structure **70**, and in particular, the intermediate wall structure **74**, can alternatively be formed by welding a plurality of separate elements together to achieve the depicted shape. Further, the intermediate wall structure **74** can be made of a plurality of sheet metal panels welded together to form a rectangular box-like shape.

For simplified manufacturing, the elements that define the compartment wall structure **70** can be separately manufactured. Specifically, the intermediate wall structure **74** can be manufactured separately from the cap protector **72**. Further, the cap protector **72** can be assembled to the fuel filler tube **22** to define the fuel filler tube assembly **12**.

A description of the fuel filler tube assembly **12** is now provided with specific reference to FIGS. **4-8**. The fuel filler tube assembly **12** basically includes the fuel filler tube **22**, the cap protector **72** and the collar **16**. The fuel filler tube assembly **12** can be assembled prior to being fitted to the vehicle **50**. For example, the cap protector **72** and the fuel filler tube **22** are welded together at welds W. Thereafter, the cap protector **72** is inserted into the opening **80** of the intermediate wall structure **74** and with a grommet G_R positioned therebetween such that the intermediate wall structure **74** and the cap protector **72** are basically friction fitted together via the grommet G_R. The collar **16** can be installed to the fuel filler tube **22** either prior to or after installation of the fuel filler tube **22** and cap protector **72** to the intermediate wall structure **74**.

As shown in FIGS. **7** and **8**, the tube receiving opening **88** and the vent openings **90** extend from the first surface **84** to the second surface **86** of the cap protector **72**.

The fuel filler tube **22** includes an outer surface **92**, an inner surface **94** (FIG. **7**), a fuel receiving end **96**, a fuel tank attachment end **98** (FIG. **1**) and alignment pins **92***a* (only one alignment pin **92***a* is shown in the drawings). The inner surface **94** defines a filler opening **94***a* and a fuel passageway that extends from the fuel receiving end **96** to the fuel tank attachment end **98**. Thus, a vehicle operator can refuel the vehicle **50** by pumping fuel into the filler opening **94***a* at the fuel receiving end **96** where it will be directed through the fuel passageway of the fuel filler tube **22** into the fuel tank **20**. As shown in FIG. **1**, the fuel tank attachment end **98** is connected to the fuel tank **20**.

The fuel receiving end **96** of the fuel filler tube **22** extends through the tube receiving opening **88** of the cap protector **72** such that the fuel receiving end **96** and the filler opening **94***a* are located within the fuel filler compartment **56**. However, the majority of the fuel tank filer tube **22** and the fuel tank attachment end **98** are located outside the fuel filler compartment **56** behind the side body panel **52**.

The fuel receiving end **96** of the fuel filler tube **22** includes an annular flange **96***a*. As shown in FIG. **7**, the annular flange **96***a* is flared radially outwardly relative to the filler opening **94***a* with a distal edge thereof extending over the vent openings **90**. Further, as viewed in FIG. **7** along a central axis of the filler opening **94***a*, the annular flange **96***a* conceals the vent openings **90**.

The two alignment pins **92***a* are disposed at opposite sides of the fuel filler tube **22**. The alignment pins **92***a* can be formed with the fuel filler tube **22** or can be metallic pins welded to the fuel filler tube **22** at predetermined locations. The alignment pins **92***a* are located on the fuel filler tube **22** in order to precisely position the collar **16** on the fuel filler tube **22** relative to the compartment wall structure **70**, as described in greater detail below.

The air vent chamber **15** is defined outside of the fuel filler compartment **56**. More specifically, the air vent chamber **15** is a space that is confined by the collar **16**, a portion of the outer surface **92** of the fuel filler tube **22** surrounded by the collar **16** and a portion of the outboard surface **70***b* of the compartment wall structure **70** covered by the collar **16**. Further, the portion of the outboard surface **70***b* of the compartment wall structure **70** covered by the collar **16** is defined by the second surface **86** of the cap protector **72**, as shown in FIG. **8**.

The collar **16** is a cylindrical or ring shaped structure that includes an annular wall **100**. The collar **16** has an outer collar surface **104** and an inner collar surface **106**. With the collar **16** installed around the fuel filler tube **22**, the annular wall **100** is located outside of the fuel filler compartment **56** adjacent to the second surface **86** of the cap protector **72**, as shown in FIG. **8**. Further, an annular surface **100***a* of the annular wall **100** contacts the outboard surface **70***b* of the

compartment wall structure **70** defined by the second surface **86** of the cap protector **72** (as shown in FIG. **8**) and can include an optional seal S located between the annular surface **100***a* of the annular wall **100** and the exterior surface **78**, thereby partially sealing the air vent chamber **15**. It should be understood from the drawings and the description herein that the seal S between the annular surface **100***a* of the annular wall **100** and the second surface **86** of the cap protector **72** can be replaced with an adhesive material or sealant material.

The annular wall **100** is basically a cylinder that completely encircles or surrounds the fuel filler tube **22**. The annular wall **100** is basically circumferentially equidistant from the outer surface **92** of the fuel tank filler tube **22**. The fuel receiving end **96** of the fuel filler tube **22** defines an axis A, and the annular wall **100** of the collar defines an axis B that is coaxial with the axis A when installed to the fuel filler tube **22**. The annular wall **100** is a side wall of the collar **16**. The collar **16** also includes an end wall **102**. The annular wall **100** has a first end that is contiguous with the end wall, and a second end opposite the end wall **102**. The end wall has an inner surface **102***b* that is continuous with the inner collar surface **106**, and an outer surface **102***c* that is continuous with the outer collar surface **104**. As shown in FIG. **8**, at least a portion of the end wall **102** extends in a direction that is perpendicular to the annular wall **100**. More specifically, the annular wall **100** extends in an axial direction along an axis A as shown in FIG. **8**. The end wall **102** extends radially inward from the annular wall **100** toward the axis A.

More specifically, the end wall **102** extends radially inwardly from the annular wall **100** with a tube receiving surface **102***a* extending from the inner surface **102***b* to the outer surface **102***c* and contacting the outer surface **92** of the fuel filler tube **22**. Another seal S can optionally be provided along the tube receiving surface **102***a* of the end wall **102** contacting the outer surface **92** of the fuel filler tube **22**, thereby further sealing the air vent chamber **15**, as shown in FIG. **8**. Hence, the air vent chamber **15** is defined by the portion of the outer surface **92** of the fuel filler tube **22** surrounded by the collar **16**, the inner collar surface **106** of the collar **16**, the end wall **102** of the collar **16** and the covered portion of the second surface **86** of the cap protector **72**. As shown in FIG. **8**, when installed to the fuel filler tube **22**, the upper end of the collar **16** defines an opening **108** that overlaps the vent openings **90** in the cap protector **72**. Specifically, the inner collar surface **106** of the collar **16** is spaced apart from the outer surface **92** defining the opening **108**. It should be understood from the drawings and the description herein that the seal S between the tube receiving surface **102***a* of the end wall **102** and the outer surface **92** of the fuel filler tube **22** can be replaced with an adhesive material or sealant material.

The collar **16** is dimensioned such that the vent openings **90** in the cap protector **72** provide fluid communication between the fuel filler compartment **56** and the air vent chamber **15**. In other words, the outer surface **92** of the fuel filler tube **22** has a diameter D_1 and the inner collar surface **106** of the collar **16** has a diameter D_2 with the diameter D_2 being larger than the diameter D_1. The vent openings **90** are located radially outward of the outer surface **92** of the fuel filler tube **22** and located radially inward of the inner collar surface **106** of the collar **16**. Consequently, the opening **108** of the collar **16** is open to the vent openings **90**. Thus, the vent openings **90** serve as a conduit or duct between the fuel filler compartment **56** and the air vent chamber **15**.

A further description of the collar **16** in accordance with the first embodiment is now provided with reference to FIGS. **6** and **9-12**. As shown in FIG. **6**, the collar **16** includes a first half collar section **110** and a second half collar section **112**. Both the first half collar section **110** and the second half collar section **112** includes snap-fitting projections **114** and mating openings **116** such that the snap-fitting projections **114** snap into the openings **116** locking the first half collar section **110** to the second half collar section **112** to form the annular ring shape of the collar **16**. Both the first half collar section **110** and the second half collar section **112** define respective sections of the inner collar surface **106** and have open areas at an upper end thereof that define the opening **108**. The first half collar section **110** and the second half collar section **112** can include a seal between their respective mating surfaces or can be sealed with an adhesive material or sealant material.

As shown in FIG. **9**, the first half collar section **110** defines half of the annular surface **100***a* of the annular wall **100**, half of the tube receiving surface **102***a* defined by the end wall **102** and half of the inner collar surface **106**. An alignment concavity **120** is formed at a central location on the inner collar surface **106**. The alignment concavity **120** is located to receive the alignment pins **92***a* such that the collar **16** is positioned relative to the fuel filler tube **22** at a predetermined location and remains in position once installed. Further, the inner collar surface **106** includes a plurality of ribs R that extend in directions parallel to one another. The ribs R are spaced apart from one another relative to an axial direction of the collar **16** and contact the outer surface **92** of the fuel filler tube **22**. Further, the ribs R are interrupted with sections being removed to form a series of gaps G. The arrangement of ribs R and gaps G are staggered at least partially defining an airflow passage way, as is described in greater detail below in the description of the second half collar section **112**.

As shown in FIGS. **10-12**, the second half collar section **112** defines a second half of the annular surface **100***a* of the annular wall **100**, a second half of the tube receiving surface **102***a* defined by the end wall **102** and a second half of the inner collar surface **106**. Another alignment concavity **120** is formed at a central location on the inner collar surface **106**. The alignment concavity **120** is located to receive the alignment pins **92***a* such that the collar **16** is positioned relative to the fuel filler tube **22** at a predetermined location and remains in position once installed. The inner collar surface **106** of the second half collar section **112** is also interrupted by a chamber opening **122** that is in fluid communication with an elbow fitting **124** installed to the outer collar surface **104** of the second half collar section **112**. The elbow fitting **124** is therefore in fluid communication with the air vent chamber **15** with the collar **16** installed to the fuel filler tube **22**. Further, like the first half collar section **110**, the inner collar surface **106** of the second half collar section **112** also includes a corresponding plurality of ribs R that extend in directions parallel to one another.

The ribs R are spaced apart from one another relative to an axial direction of the collar **16**. Further, the ribs R are interrupted with sections being removed to form a series of gaps G. The arrangement of ribs R and gaps G are staggered at least partially defining the above mentioned airflow passage way. Specifically, the airflow passageway is a non-linear, staggered path that extends from the opening **108** and eventually flows to the chamber opening **122**. When the first half collar section **110** and the second half collar section **112** are installed to one another and installed to the fuel filler tube **22**, the ribs R and gaps G of the first half collar section

110 and the second half collar section 112 combine to make a labyrinth or maze that venting air must follow as it travels between the fuel filler compartment 56, the air vent chamber 15, the chamber opening 122 and the line L_3. The airflow passageway acts as a filter, preventing debris and moisture from passing in or out of the chamber opening 122. Also, the chamber opening 122 includes a screen 126 that also serves as a filter to prevent insects and/or debris from moving through the chamber opening 122. The screen 126 can have a fine mesh material with very small openings or can be a coarser screen material with larger openings. As shown in FIG. 8, the chamber opening 122 and the elbow fitting 124 are located above a majority of the air vent chamber 15. Hence, debris and moisture that might enter the air vent chamber 15 is further inhibited by gravity from entering the chamber opening 122.

When the first half collar section 110 and the second half collar section 112 are attached to one another defining the collar 16, the annular surface 100*a* of the annular wall 100 is a circular or annular shaped surface that contacts the second surface 86 of the cap protector 72, as described above, Further, when the first half collar section 110 and the second half collar section 112 are attached to one another defining the collar 16, the tube receiving surface 102*a* is a surface that completely encircles or surrounds the outer surface 92 of the fuel filler tube 22. In the depicted embodiment, the tube receiving surface 102*a* is not annular but has a serpentine shape due to the inclusion of symmetrical recesses 128.

The first half collar section 110 and the second half collar section 112 each include the recesses 128. As shown in FIG. 5, the recesses 128 provide space for the line L_1 (L_2) that vents the fuel filler tube 22 below the removable fuel filler cap 58.

As shown in FIG. 3 the elbow fitting 124 of the collar 16 is connected to the line L_3. Hence, the air vent chamber 15 is in fluid communication with the filter canister 30. It should be understood from the drawings and the description herein that the removable fuel filler cap 58 does not impede the movement of air between the air vent chamber 15 and the fuel filler compartment 56.

It should also be understood from the drawings and the description herein that the first half collar section 110 and the second half collar section 112 are identical to one another except that the second half collar section 112 includes the chamber opening 122, the elbow fitting 124 and the screen 126. Otherwise, the first half collar section 110 and the second half collar section 112 are identical and mate together to define the collar 16 in the first embodiment.

It should be understood from the drawings and the description herein that the air vent chamber structure 14 can be constructed and/or formed in any of a variety of ways. For example, the collar 16 can be replaced with a half collar arrangement that attaches to the fuel filler tube 22 in order to define the air vent chamber 15.

It should also be understood from the drawings and description herein, that the fuel door 54 does not provide an air tight seal between an exterior of the vehicle 50 and the fuel filler compartment 56. Therefore, air can move relatively freely between the fuel filler compartment 56 and the exterior of the vehicle 50. However, the fuel door 54 protects and covers the fuel filler compartment 56 preventing debris and dirt from entering the fuel filler compartment 56. Therefore, the location of the air vent chamber 15 and the ability for air to move freely between the air vent chamber 15 and the fuel filler compartment 56 provides a clean environment for the movement of air to and from the filter canister 30 during operation of the fuel vapor recovery system 10.

In the depicted embodiment, the inner collar surface 106 of the collar 16 (an end wall) and outer surface 92 of the fuel filler tube 22 are parallel to one another with the collar 16 fully installed.

Second Embodiment

Referring now to FIGS. 13 and 14, a fuel filler tube assembly 12' in accordance with a second embodiment will now be explained. In view of the similarity between the first and second embodiments, the parts of the second embodiment that are identical to the parts of the first embodiment will be given the same reference numerals as the parts of the first embodiment. Moreover, the descriptions of the parts of the second embodiment that are identical to the parts of the first embodiment may be omitted for the sake of brevity. The parts of the second embodiment that differ from the parts of the first embodiment will be indicated with a single prime (').

In the second embodiment, the fuel filler tube assembly 12' replaces the fuel filler tube assembly 12 of the first embodiment in the fuel vapor recovery system 10, but includes many of the structural elements of the fuel filler tube assembly 12 of the first embodiment. In the second embodiment, the fuel filler tube assembly 12' includes the fuel filler tube 22 of the first embodiment and the cap protector 72. However, in the second embodiment, the collar 16 from the air vent chamber structure 14 is eliminated and replaced with a collar 16' from an air vent chamber structure 14'. The collar 16' only extends part way around the fuel filler tube 22. The collar 16' includes a first attachment flange F_1 and a second attachment flange F_2 that are fixedly attached to the fuel filler tube 22 at circumferentially spaced apart locations. The first wall 100' of the air vent chamber structure 14' extends from the first attachment flange F_1 to the second attachment flange F_2. The first wall 100' partially surrounds the outer surface 92 of the fuel filler tube 22 to define an air vent chamber 15' between the first wall 100', the second wall 102', the outer surface 92 of the fuel filler tube 22, and the exterior surface 86 of the cap protector 72.

In the first embodiment, the collar 16 can be made of a plastic or polymer material. In the second embodiment, the collar 16' is made of metal, and the first attachment flange F_1 and the second attachment flange F_2 are welded to the side of the fuel filler tube 22 at welds W, thereby defining the air vent chamber 15'. The collar 16' includes ribs R having gaps G, forming a labyrinth that defines an air flow passageway similar to that of the collar 16 of the first embodiment. The collar 16' further includes the chamber opening 122, the elbow fitting 124 and the screen 126 of the first embodiment. The collar 16' joins with the cap protector 72 providing ventilation between the air vent chamber 15' and the fuel filler compartment 56 in a manner consistent with the first embodiment.

The controller (not shown) of the fuel vapor recovery system 10 preferably includes a microcomputer with a fuel vapor recovery system control program that controls the fuel vapor recovery system 10. The controller can also include other conventional components such as an input interface circuit, an output interface circuit, and storage devices such as a ROM (Read Only Memory) device and a RAM (Random Access Memory) device. The microcomputer of the controller is programmed to control the fuel vapor recovery system 10. The internal RAM of the controller stores statuses of operational flags and various control data. The

internal ROM of the controller stores the information necessary for various operations of the fuel vapor recovery system **10**. The controller is capable of selectively controlling any of the components of the control system in accordance with the control program. It will be apparent to those skilled in the art from this disclosure that the precise structure and algorithms for the controller of the fuel vapor recovery system **10** can be any combination of hardware and software that will carry out the functions of the present invention.

There are various components of the fuel vapor recovery system **10** and the vehicle **50** that are conventional components that are well known in the art. Since these components are well known in the art, these structures will not be discussed or illustrated in detail herein. Rather, it will be apparent to those skilled in the art from this disclosure that the components can be any type of structure and/or programming that can be used to carry out the present invention.

General Interpretation of Terms

In understanding the scope of the present invention, the term "comprising" and its derivatives, as used herein, are intended to be open ended terms that specify the presence of the stated features, elements, components, groups, integers, and/or steps, but do not exclude the presence of other unstated features, elements, components, groups, integers and/or steps. The foregoing also applies to words having similar meanings such as the terms, "including", "having" and their derivatives. Also, the terms "part," "section," "portion," "member" or "element" when used in the singular can have the dual meaning of a single part or a plurality of parts. Also as used herein to describe the above embodiments, the following directional terms "forward", "rearward", "above", "downward", "vertical", "horizontal", "below" and "transverse" as well as any other similar directional terms refer to those directions of a vehicle equipped with the fuel vapor recovery system. Accordingly, these terms, as utilized to describe the present invention should be interpreted relative to a vehicle equipped with the fuel vapor recovery system.

The term "detect" as used herein to describe an operation or function carried out by a component, a section, a device or the like includes a component, a section, a device or the like that does not require physical detection, but rather includes determining, measuring, modeling, predicting or computing or the like to carry out the operation or function.

The term "configured" as used herein to describe a component, section or part of a device includes hardware and/or software that is constructed and/or programmed to carry out the desired function.

The terms of degree such as "substantially", "about" and "approximately" as used herein mean a reasonable amount of deviation of the modified term such that the end result is not significantly changed.

While only selected embodiments have been chosen to illustrate the present invention, it will be apparent to those skilled in the art from this disclosure that various changes and modifications can be made herein without departing from the scope of the invention as defined in the appended claims. For example, the size, shape, location or orientation of the various components can be changed as needed and/or desired. Components that are shown directly connected or contacting each other can have intermediate structures disposed between them. The functions of one element can be performed by two, and vice versa. The structures and functions of one embodiment can be adopted in another embodiment. It is not necessary for all advantages to be present in a particular embodiment at the same time. Every feature which is unique from the prior art, alone or in combination with other features, also should be considered a separate description of further inventions by the applicant, including the structural and/or functional concepts embodied by such features. Thus, the foregoing descriptions of the embodiments according to the present invention are provided for illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

What is claimed is:

1. A vehicle fuel filler tube assembly comprising:

a fuel filler tube having an outer surface, a fuel receiving end and a fuel tank attachment end opposite the fuel receiving end, the fuel filler tube having a cylindrical shape proximate the fuel receiving end;

a cap protector having a first surface defining a fuel filler compartment and a second surface opposite the first surface outside of the fuel filler compartment, the cap protector defining an upper tube receiving opening that extends from the first surface to the second surface with the fuel filler tube extending therethrough, the cap protector defining an upper vent inlet opening that extends from the first surface to the second surface at a location spaced apart from the upper tube receiving opening;

a collar circumscribing the fuel receiving end of the fuel filler tube, the collar comprising:

an end wall having an inner surface and an outer surface with a tube receiving surface extending from the inner surface to the outer surface and defining a lower tube receiving opening having a first diameter, the fuel filler tube extending through the lower tube receiving opening with the tube receiving surface contacting the outer surface of the fuel filler tube; and

a side wall extending from the end wall, the side wall having a first end that is contiguous with the end wall and a second end opposite the end wall, the side wall having an inner collar surface and an outer collar surface that both have an arcuate contour defining a cylindrical shape, the second end having a flat arcuate end surface that contacts the second surface of the cap protector, the side wall and the outer surface of the fuel filler tube defining a gap therebetween at the second end, the gap further defining a lower vent inlet opening, the lower vent inlet opening having a second diameter defined by the inner collar surface at the second end, the second diameter being larger than the first diameter, the flat arcuate end surface of the second end of the side wall encircling the upper vent inlet opening and the upper tube receiving opening, the side wall further defining a chamber opening spaced apart from the second end that extends from the inner collar surface to the outer collar surface, the inner collar surface including a plurality of first ribs and a plurality of second ribs that protrude in a radially inward directions and extend along the arcuate contours of the inner collar surface, the plurality of first ribs being parallel to one another, at least one of the plurality of second ribs extending between a first one of the plurality of first ribs to a second one of the plurality of first ribs, such that the plurality of first ribs, the plurality of second ribs, the lower vent inlet opening and the outer surface of the

fuel filler tube define a non-linear labyrinth path between the upper vent inlet opening and the chamber opening.

2. The vehicle fuel filler tube assembly according to claim **1**, wherein

the inner surface of the end wall and the inner collar surface of the side wall are perpendicular to one another.

3. The vehicle fuel filler tube assembly according to claim **1**, wherein

the inner surface of the end wall and the inner collar surface of the side wall at least partially define an air vent chamber.

4. The vehicle fuel filler tube assembly according to claim **1**, wherein the chamber opening extends perpendicular to the vent opening.

5. The vehicle fuel filler tube assembly according to claim **1**, wherein

the inner collar surface includes a screen fixedly attached thereto that covers the chamber opening.

6. The vehicle fuel filler tube assembly according to claim **1**, wherein

the collar includes a first collar portion and a second collar portion,

the first collar portion including a first snap fitting projection and a first attachment recess, and

the second collar portion including a second snap fitting projection and a second attachment recess, such that with the first snap fitting projection fitted to the second attachment recess and the second snap fitting projection fitted to the first attachment recess.

7. The vehicle fuel filler tube assembly according to claim **1**, wherein

the outer surface of the fuel filler tube, the inner surface of the end wall and the inner collar surface of the side wall at least partially define an air vent chamber.

8. The vehicle fuel filler tube assembly according to claim **1**, wherein

the outer surface of the fuel filler tube includes an alignment projection, and the collar includes an alignment concavity formed on the inner collar surface that is dimensioned to receive the alignment projection.

9. The vehicle fuel filler tube assembly according to claim **1**, wherein

the second surface of the cap protector, the outer surface of the fuel filler tube, the inner surface of the end wall, and the inner collar surface of the side wall define an air vent chamber, and the first vent inlet opening and the second vent inlet opening are in fluid communication such that the air vent chamber is in fluid communication with the fuel filler compartment.

10. The vehicle fuel filler tube assembly according to claim **1**, wherein

the non-linear labyrinth path defines a plurality of filter passages between the upper vent inlet opening and the chamber opening.

11. The vehicle fuel filler tube assembly according to claim **1**, wherein

the plurality of second ribs extend in directions perpendicular to the plurality of first ribs.

12. The vehicle fuel filler tube assembly according to claim **1**, wherein

the fuel receiving end of the fuel filler tube defines a central axis extending therethrough, and

the collar defines a central axis extending therethrough that is coaxially aligned with the central axis of the fuel receiving end of the fuel filler tube.

13. The vehicle fuel filler tube assembly according to claim **1**, wherein

the cap protector is generally planar in an area around the upper tube receiving opening, the upper vent inlet opening and at a location of contact with the flat arcuate end surface of the second end.

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